SECTION - TWO

BIOMASS STUDIES
CHAPTER IV

INTRODUCTION AND REVIEW

In spite of a greater interest of ecologists in the production studies of organic matter in different ecosystems, work of this nature on the forests of tropical regions is very scanty. This is mainly owing to a great biological richness and diversity of species. Uneven aged crop of plant species and non-availability of suitable methods to determine the tree-age have frequently posed problems in measuring organic productivity.

An appreciable amount of data is now available from the temperate regions because it had been easier to determine the age of conifers and other hardwood species from the growth-ring counts and hence to measure their organic productivity. The density of trees is also more or less uniform in these forests resulting in easier computation of biomass data and other parameters.
In the absence of a knowledge of plant age, Newbould (1967) has suggested that even other parameters of trees, like CBH, dbh or height can also be used with sufficient accuracy in estimating biomass and forest productivity in temperate regions.

But, in the tropical dry deciduous forests where majority of the tree species possesses the power of regeneration by coppice growth, measurements of productivity depending upon CBH, dbh or height increment cannot be a reliable parameter. The CBH of a tree in the early 25 to 30 years of coppice growth is supposed to be significantly higher in comparison to a normal tree derived from a seed. The CBH of a coppiced tree is also dependent upon the age of the stump.

Therefore, in these regions, there appears a complete lack of attempts to correlate biomass and productivity with any of the tree parameters or age of the stand. Application of methods or generalizations of temperate regions as recommended by Ovington (1956, 1957), Newbould (1967) and others have yet to be tested with caution and modifications suiting to the vegetation of tropical zone.

On the basis of a large number of studies Newbould (1967) and many other workers in temperate regions have recommended that successive fellings of forest trees can be avoided for measuring the organic matter production, as one can resort to the measurement of organic matter in relation to CBH, dbh or
height of tree species and then the computation of the data can be done to find out a fairly reliable information.

A survey of the literature shows that Boysen Jenson as early as 1932 emphasized the harvest method in relation to forests, for measuring the organic matter production. This method began to get prominence by later workers in other plant communities throughout the world. Kittredge (1944) while studying the forest influences also estimated foliage production. Initial concentrated efforts for measuring biomass production by trees and their various components and other minor strata of forests were made by Ovington (1956, 1957), Pearsall (1956) and Ovington and Madgwick (1959). Ovington (1962) has reviewed the world literature on forest biomass data and related studies in an ecosystem context. Ovington (1956) could find out a relationship between form of tree and dry matter content. He has described the efficiency of trees to utilize site conditions.

Ando et al. (1959) measured the amounts of various plant parts of Cryptomaria japonica by sampling method while Rutler (1955) found out the relation between dry weight of the tree and linear measure of growth in two young conifers—Pinus sylvestris and Picea sitchensis. He could conclude that at any time before the canopy was closed, dry weight was more closely related to the basal diameter of the tree than height. Rutler (1955) proposed a view that within fairly wide limits of
thinning intensity, the mean height of a stand remained constant while the mean diameter was inversely related to density. When thirty to fifty plants were taken into consideration, the standard errors attached to the estimates were approximately equivalent for both the species (Pinus + 13%, Picea + 18%) while standard errors attached to weight estimates from height measurements were very high (Pinus -58 to + 139%, Picea -47 to + 89%). Thus, determination of standing biomass by height measurement was not appreciable statistically. The results obtained by using the expressions, which combined diameter and height were also insignificant.

Kumura (1960) collected some data for primary productivity of a warm temperate laurel forest while Bray and Dukkievicz (1963) determined the biomass and productivity of two (Populus) forests.

Keen and Weetman (1961) after an exhaustive study of plant productivity, suggested two methods for determination of standing crop and organic matter production in forests. According to the first method biomass can be estimated directly by weighing but according to the other method, biomass can be measured indirectly by volume and density of various components of the tree. He proposed the following formula -

\[ P_n = B + L + G \]
where \( P_n \) = Net production
\[ L = \text{Losses by death or shedding during } t \]
\[ B = \text{Biomass change during } t \]
\[ t = \text{Change in time} \]
\[ G = \text{Losses by consumers} \]

Becking (1962) defined precisely the terms concerning productivity of organic matter by plants. Accordingly to him, the assimilation of organic matter by a plant during a certain period, including the amount used up in respiration is 'Gross primary production' while gross production minus respiration is 'Net primary production', which is known simply as primary production. If ash content is excluded from it, 'Organic production' can be found out. 'Biomass' on the other hand is the total amount of living matter present at a given moment in any ecosystem.

According to Anderson (1970) irrespective of any definition, the basic need in the estimation of biomass and production in a tree layer involves four important steps, which are as follows:

(i) Stand analysis of non-destructive measurements,
(ii) Destructive measurements of the sampled trees,
(iii) Application of the stand analysis to the regression of sampled trees, and
(iv) Additional observations regarding litter-fall, etc.
Baskerville (1963, 1965) in an attempt to find out a short- 
cut method to the above object of measuring the biomass and 
organic matter production developed the concept of an average 
tree, which is as follows:

(i) Tree of mean height,
(ii) Tree of mean diameter,
(iii) Tree of mean volume,
(iv) Tree of mean basal area, and
(v) Average co-dominant tree.

After estimating the component dry weights and the total 
standing biomass in a 0.2 acre plot by energy-tree-summation 
method, he could conclude that the average tree approach was 
useful only where a rough estimate of the total biomass was 
desired. The short-cut techniques gave a high percentage of 
error in all the components.

Results from an exploratory study have been collected from 
various approaches (Tadaki et al., 1960, 1961, 1962; Rees and 
Tinkler, 1963). Attiwill (1962) determined a direct relationship 
between the crown weight and stem diameter in *Eucalyptus*. He 
also measured the branch dry weight and leaf area from branch 
girth. Westlake (1963) reviewed several estimations on plant 
productivity in different forests and gave the following probable 
values for average annual net primary production in various 
zones of the world:
<table>
<thead>
<tr>
<th>Forest type</th>
<th>Tons/ha/yr.</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperate deciduous forest</td>
<td>12</td>
<td>± 25%</td>
</tr>
<tr>
<td>Temperate coniferous forests</td>
<td>28</td>
<td>± 25%</td>
</tr>
<tr>
<td>Tropical rain forest</td>
<td>50</td>
<td>± 20%</td>
</tr>
</tbody>
</table>

Nomoto (1964) in a review has also compiled the work on productivity studies in beech forests of Japan.

During the last decade, a large number of papers have appeared dealing with productivity in the forests. Some of the notable contributions are those of Ogino et al. (1964), Weetman and Harland (1964), Young et al. (1964, 1965), Ogawa et al. (1965), Ovington (1965), Attiwill (1966), Loomis et al. (1966), Peterken and Newbould (1966), Satoo (1966, 1968), Kira et al. (1967), Whittaker and Woodwell (1963), Holland (1969), Kinght and Loucks (1969), Whittaker (1969), Andersen (1970), Post (1970), Axelsson (1972) and Nihlsgord (1972) etc.

Ogino et al. (1964) have estimated the standing biomass of a dry dipterocarp and a dry evergreen forest by allometric method. They found out 91.37 and 250.48 tons dry organic matter per ha. in two stands of dry dipterocarp forest while 220.94 and 403.77 dry organic matter in two stands of the dry evergreen forest.
Weetman and Harland (1964) determined foliage and wood production in *Picea mariana* and prepared diameter tables for estimating total dry weight of needles per tree. They concluded from the data that the dominant species of the forests were less efficient producers of organic matter per unit weight of needles, than the suppressed trees. Dominant, intermediate and suppressed trees were estimated to have produced 0.26, 0.31 and 0.34 Kg. dry stem wood/tree/year, respectively. The needles showed 9.8 ha. of photosynthetic area per ha. and the needle weight/tree was linearly related to stem volume increment. They also found out that on an average 74147 Kg. of bole wood, 10791 Kg. of branches and 8556 Kg. of needles were present per ha. in a 65-year old plantation of *P. mariana*.

Loomis *et al.* (1966) found out relationship between crown-weight and stem diameter in *Pinus echinata*. They established the fact that stand density has apparently no effect on such relationships. They could also give the generalization that bole diameter at the base of the crown was the best single estimator of foliage and branch weights. dbh and crown lengths were poor estimators when used alone. However, they could be used easily in combination but adjustments were necessary in estimating the weights of irregular crowns.

Peterken and Newbould (1966) after determining the dry matter production in *Ilex aquifolium* concluded that it was a
tree having low trunk biomass supporting an exceptionally heavy canopy.

Kira et al. (1967) in a monsoon, savana and rain forest determined the gross and net production of organic matter per annum and revealed the dynamic equilibrium in a climax forest in terms of the balance between input and output of the matter to and from the standing biomass.

Newbould (1967) estimated the primary production in very minor components of the trees like bud-scales, flowers and fruits, etc. According to him, stem production was the major part and needed special attention. He suggested that the principle of such estimations should be the complete enumeration and measurements of stems followed by a correlation between tree dimension and its dry weight.

In a study, Whittaker and Woodwell (1968) suggested that four types of areas should be taken into account in the field while carrying out production studies. These areas are:

(i) Sample area,
(ii) Buffer area,
(iii) Measurement area, and
(iv) Study area.

Holland (1969) estimated the aerial biomass and its annual increment in two forests of mallee vegetation which differed
in species composition and age. He suggested that both the forests were fairly productive even during drought.

Knight and Loucks (1969) have also analysed quantitatively the upland forest vegetation in Wisconsin and determined relationship between plant productivity and gross morphology of the trees, and also vegetation and environment, i.e., deciduousness, shade tolerance, method of seed dispersal and fire resistance, etc. They demonstrated that the upland forest communities could be distinguished using the above described features.

Post (1970) determined the standing crop in Acer spicatum which ranged from 0.74 ton/ha. at 1 year to 40.45 tons/ha. at 26 years of age. In Abies balsamea at 25 years, the standing crop was 55.55 tons/ha. Annual increments in organic matter were 0.81 ton/ha./yr. in stem wood, 0.51 ton/ha./yr. in branches, 0.17 ton/ha./yr. in stem bark, and 0.03 ton/ha./yr. in foliage in A. spicatum. This annual weight increment was constant from 8 years to 26 years of age while in A. balsamea it was initially very low but raised at 25 year age.

Nihlgord (1972) estimated the plant biomass, primary productivity and distribution of organic matter in various plant parts in a beech and a planted spruce forest. The standing crop was 1069 Kg. in a 73 years old beech tree while it was 423 Kg. in a 55 years old spruce tree. The shoot/root
ratios were 6.8 and 5.5 respectively.

In India, literature on such studies is very scanty. First paper on tree biomass and production studies was that of Misra et al. (1967). Though ample data are available for volume tables of numerous important timber tree species, like Tectona grandis, Terminalia tomentosa and Anogeissus latifolia prepared by Laurie and Sant Ram (1940), Griffith (1947) and Dabral and Lala (1964) respectively. Such tables indicated the differences in the volume of wood of timber value and the total available volume of the wood.

During the last few years, some studies have been initiated following the themes of IBP. Notable publications are those of Pandeya et al. (1967, 1970, 1972), Vyas et al. (1971, 1972, 1973), Bandhu (1970, 1972), Garg et al. (1972), Agrawal (1972), Mishra and Kandya (1973) and Kandya (1974).

Bandhu (1970) presented the results of the investigations on productive structure of forests with an emphasis on Shorea robusta while Vyas et al. (1971a, b, c, 1972, 1973) estimated the plant biomass and production relations in Tectona grandis, Erythrina sabulosa, Mitragyna parviflora, Butea monosperma, Adina cordifolia and Anogeissus latifolia. Pandeya et al. (1967, 1970, 1972) determined the net primary productivity in five important tree species of the forests of Gujrat. Misra (1969, 1970) reviewed the work done in India. Recently, Bandhu
(1972) presented the total available Indian data on primary production by forests, in an international woodland workshop emphasizing the modelling of forest ecosystems of various places. This has provided a sound foundation to the understanding of tropical deciduous forest ecosystems.

Many aspects of the forest ecosystems of Sagar have been studied earlier by a number of workers, i.e., structure and composition of the forests by Misra and Joshi (1952), Bhatia (1958) and Mishra (1961); formation, development and decomposition of litter layers by Bhatnagar (1968); autecological investigations of dominant tree species by Bhatia (1954), Sharma (1955) and Rathore (1968); distribution of soil fungi in the organic matter overlying the forest soils by Saksena (1955), Vyas (1963), Verma (1964), Dakwale (1966) and Agrawal (1970) and autecology of the forest herbs by Mall (1953) and Mall and Raina (1959). No work appears to have been done on aspects like production of organic matter by trees, its inputs and outputs in the forest ecosystems, flow of energy and quantities of minerals circulating within them. Work of this nature has been done on the grassland ecosystems of Sagar by Jain (1971).

The present investigation primarily deals with organic matter production in above and underground parts of 4 selected tree species of Sagar. In 5 forest stands of the district,
covering the major bio-edaphic ranges.

The entire set of foliage gave an idea of total photosynthetic area of a tree, which was used for determining organic matter production in relation to the foliage surface. Various biomass ratios, i.e., trunk/branch + twigs, nonphotosynthetic/photosynthetic and shoot/root have also been determined.

The data on standing biomass and productivity of organic matter were converted to energy values by simple multiplication of caloric values of various plant parts with the corresponding dry weights of these plant parts. Organic matter and energy budget sheets have been prepared for six selected tree species of the forests of Sagar.